

## DESCRIPTION

NETWORK-LOAD DISPERSION SYSTEM, METHOD THEREFOR, AND  
RECORDING MEDIUM RECORDED WITH PROGRAM FOR ACHIEVING THIS

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METHOD

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of  
PCT/JP99/04438, filed on August 18, 1999, the contents  
being incorporated herein by reference.

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## BACKGROUND OF THE INVENTION

## Field of the Invention

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The present invention relates to a system for  
dispersing the load of a network, a method therefor, and  
a recording medium recorded with a program for executing  
this method, in data communications between a central  
computer and a plurality of remote nodes that are  
connected to this central computer via a broadband  
network. Particularly, this invention relates to a  
system for dispersing the load of a network, a method  
therefor, and a recording medium recorded with a program  
for executing this method, in a network in which a  
monitoring unit carries out polling by avoiding a local  
busy status of network traffic in order to monitor a  
plurality of remote nodes that are connected via a  
broadband network.

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## Description of the Related Art

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Nowadays, in the information community, data  
communications have been carried out between a central  
computer and a plurality of remote computers that are  
connected to this central computer via a network.  
Further, in recent years, high-speed transmission and the  
application of multimedia have become increasingly  
important in a broadband network that realizes  
communications between LANs. High-speed data  
communications including image data have become  
accordingly important.

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As broadband networks, there are a B-ISDN (Broadband

Integrated Services Digital Network) that is based on an asynchronous transfer mode (ATM) for covering transmission speeds to a few M-bits / sec., a frame relay system for covering transmission speeds up to about 1.5 M-bits / sec., and a network that is based on an SMDS (Switched Multi-megabit Data Service) that is a connection-less data communication system for covering transmission speeds of a few M-bits / sec. to a few tens of M-bits / sec.

In a data communication system in which a plurality of remote computers are connected to a central computer via a broadband network, the central computer monitors the plurality of remote computers as follows. The central computer transmits mails to the plurality of remote computers, and the remote computers receive these mails and send return mails to the central computer. When the central computer carries out polling to the plurality of remote computers, the data communications are usually carried out according to the IP (Internet Protocol).

However, in the above data communication system, there is the following problem. The central computer does not know through which communication route of the broadband network the central computer carries out data communications with the remote computers. For monitoring or other purpose, the host computer as a mail transmission origin sequentially transmits data to the plurality of remote computers that are the mail arrival destinations, according to the IP addresses. Then, the central computer receives return mails from these remote computers. During this period, there may occur local traffic congestion in the communication routes within the broadband network. As these routes become busy, there may occur time periods when data communications, used for other business, will be unavailable.

#### SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention

to provide a system, for dispersing the load of a network, that can solve the above problem and avoid local traffic congestion in a communication route within a broadband network, a method therefor, and a recording medium recorded with a program for executing this method.

In order to achieve the above object, according to a first aspect of the present invention, there is provided a system for dispersing the load of a network in data communications between a central computer and a plurality of remote nodes that are connected to the central computer via a broadband network, wherein the central computer comprises: a communication order determining unit that determines an order of communications between the central computer and the plurality of remote nodes, in order to avoid local traffic congestion in a communication route within the broadband network; a communication interval determining unit that determines a communication interval between a remote node with which the central computer communicates this time and a remote node with which the central computer communicates next time, among the plurality of remote nodes that communicate with the central computer; and a communication control unit that controls data communications between the central computer and the plurality of remote nodes, according to the communication order and the communication interval.

According to a second aspect of the invention, there is provided a system for dispersing the load of a network according to the above aspect, wherein the communication interval is obtained as follows: a repetition period for repetitively executing communications with the whole plurality of remote nodes is divided by a total number of the remote nodes, and a quotient obtained is subtracted by a processing time per one node thereby to obtain the communication interval which includes a communication waiting time.

According to a third aspect of the invention, there

is provided a system for dispersing the load of a network according to the above aspect, wherein the plurality of remote nodes are divided into groups of a plurality of transmission lines, and the frequency that the  
5 transmission lines divided into the groups are used for communications is increased in proportion to the number of remote nodes that are accommodated in the divided groups of transmission lines.

According to a fourth aspect of the invention, there  
10 is provided a system for dispersing the load of a network according to the above aspect, wherein the plurality of remote nodes are divided into groups of a plurality of transmission lines, and the frequency that the  
15 transmission lines divided into the groups are used for communications is increased in proportion to the line speeds of the divided transmission lines.

In order to achieve the above object, according to a fifth aspect of the invention, there is provided a system for dispersing the load of a network in a monitoring unit that carries out polling to a plurality of nodes to be  
20 monitored that are connected via a broadband network, wherein the monitoring unit comprises: a polling order determining unit that determines an order of polling the plurality of nodes to be monitored; a polling interval  
25 determining unit that determines a polling interval between the nodes to be monitored; and a control unit that controls the monitoring unit to carry out polling of the plurality of nodes to be monitored, according to the polling order and the polling interval.

In order to achieve the above object, according to a  
30 sixth aspect of the invention, there is provided a method of dispersing the load of a network in data communications between a central computer and a plurality of remote nodes that are connected to the central  
35 computer via a broadband network, the method comprising the steps of: determining an order of communications between the central computer and the plurality of remote

nodes, in order to avoid local traffic congestion in a communication route within the broadband network; determining a communication interval between a remote node with which the central computer communicates this time and a remote node with which the central computer communicates next time, among the plurality of remote nodes that communicate with the central computer; and controlling data communications between the central computer and the plurality of remote nodes, according to the communication order and the communication interval.

According to a seventh aspect of the invention, there is provided a method of dispersing the load of a network according to the above aspect, wherein the communication interval is obtained as follows: a repetition period for repetitively executing communications with the whole plurality of remote nodes is divided by a total number of the remote nodes, and a quotient obtained is subtracted by a processing time per one node thereby to obtain the communication interval which includes a communication waiting time.

According to an eighth aspect of the invention, there is provided a method of dispersing the load of a network according to the above aspect, wherein the plurality of remote nodes are divided into groups of a plurality of transmission lines, and the frequency that the transmission lines divided into the groups are used for communications is increased in proportion to the number of remote nodes that are accommodated in the divided groups of transmission lines.

According to a ninth aspect of the invention, there is provided a method of dispersing the load of a network according to the above aspect, wherein the plurality of remote nodes are divided into groups of a plurality of transmission lines, and the frequency that the transmission lines divided into the groups are used for communications is increased in proportion to the line speeds of the divided transmission lines.

In order to achieve the above object, according to a tenth aspect of the invention, there is provided a method of dispersing the load of a network in a monitoring unit that carries out polling to a plurality of nodes to be monitored that are connected via a broadband network, the method comprising the steps of: determining an order of polling the plurality of nodes to be monitored; determining a polling interval between the nodes to be monitored; and controlling the monitoring unit to carry out polling of the plurality of nodes to be monitored, according to the polling order and the polling interval.

In order to achieve the above object, according to an eleventh aspect of the invention, there is provided a computer-readable recording medium recorded with a program that is used in a system for dispersing the load of a network in data communications between a central computer and a plurality of remote nodes that are connected to the central computer via a broadband network, wherein the recording medium has been recorded with a program for making the central computer function as: a communication order determining unit that determines an order of communications between the central computer and the plurality of remote nodes, in order to avoid local traffic congestion in a communication route within the broadband network; a communication interval determining unit that determines a communication interval between a remote node with which the central computer communicates this time and a remote node with which the central computer communicates next time, among the plurality of remote nodes that communicate with the central computer; and a communication control unit that controls data communications between the central computer and the plurality of remote nodes, according to the communication order and the communication interval.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic structure diagram of a system

for dispersing the load of a network according to one embodiment of the present invention.

Fig. 2 is a flowchart that shows a processing order of a monitoring unit.

5        Fig. 3 is a flowchart that shows a processing order for determining an order of polling nodes to be monitored.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

10        Fig. 1 is a schematic structure diagram of a system for dispersing the load of a network according to one embodiment of the present invention. In Fig. 1, a monitoring unit 1 is connected to three center routers A, B and C indicated by reference numbers 11 to 13  
15        respectively, via a LAN. The center routers 11 to 13 are connected to 386 remote nodes in total (hereinafter, to be simply referred to as a node) via a frame relay 2 as a broadband network. A network between the center routers 11 to 13 and the 386 nodes is constructed of a WAN (Wide  
20        Area Network) that has a relatively low transmission speed compared to that of the LAN.

      The center router 11 is connected to nodes that are divided into three groups corresponding to transmission lines 1-1, 1-2, and 1-3 respectively, through these  
25        transmission lines and via the frame relay 2. The center router 12 is connected to nodes that are divided into three groups corresponding to transmission lines 2-1, 2-2, and 2-3 respectively, through these transmission lines and via the frame relay 2. The center router 13 is  
30        connected to nodes that are divided into four groups corresponding to transmission lines 3-1, 3-2, 3-3, and 3-4 respectively, through these transmission lines and via the frame relay 2. The total 386 nodes that are divided into these ten groups are connected to the monitoring  
35        unit 1 via the frame relay 2.

      Each of the transmission lines 1-1, 1-2, 1-3, 2-1, --, and 3-3 has a transmission speed of 768 Kbps, and the

transmission line 3-4 has a transmission speed of 384 Kbps. Further, each node has a transmission speed of 64 Kbps.

In the example shown in Fig. 1, each group of the nodes is constructed of 19 nodes, 38 nodes, or 40 nodes. Each node is on an individual LAN not shown, and a server and clients are connected on this LAN. In the present embodiment, each node is an object that is to be monitored. It is also possible to structure the embodiment of the present invention such that the server and the clients on the LAN connected to each node become objects that are to be monitored.

In monitoring the 368 nodes, the monitoring unit 1 does not carry out polling based on the IP address of each node. Instead, in order to avoid local traffic congestion in a communication route within the WAN, the monitoring unit 1 carries out polling as follows by taking into account the dispersion of the load of the network.

Fig. 2 is a flowchart that shows a processing order of the monitoring unit.

First, the monitoring unit 1 carries out initialization at step S1. In other words, the monitoring unit 1 collects center router information from the center routers 11 to 13, and sets polling information.

1. The center router information includes the following.

① Names of transmission lines that are connected to respective center lines, that is, the transmission lines 1-1, 1-2, 1-3, 2-1, ---, 3-3, and 3-4.

② IP addresses of nodes that are accommodated in respective transmission lines.

③ Line speeds of transmission lines, that is, the transmission speed 768 Kbps of the transmission lines 1-1, 1-2, 1-3, 2-1, ---, and 3-3, respectively, and the transmission speed 384 Kbps of the transmission line 3-4.



2. The polling information includes the following.

① A processing time of the monitoring unit, for example, 0.01 sec.

② A polling period, for example, 15 min.

5       The polling period is a repetition period of polling the whole nodes at the time of polling the whole node for the purpose of monitoring.

③ A number of MIB obtained, for example, ten per one polling.

10       ④ A maximum node response time, for example, 0.1 sec.

The maximum node response time is a node response time that is a longest among the response times of the whole nodes.

15       ⑤ Line efficiency, for example, 90%.

The line efficiency is approximately 90%, as the broadband network is constructed of frame relays. The line efficiency is approximately 80% when the broadband network is constructed of a B-ISDN.

20       Next, at step S2, the monitoring unit 1 calculates a data transmission / reception quantity from the number of obtained MIB, based on the following expression (1).

      Data transmission / reception quantity  
      = number of obtained MIB x average size of packets  
25       transmitted / received --- (1)

      The MIB (Management Information Base) is information that the network monitoring protocol of the IP base uses. In this case, the MIB is notification information that is transmitted from a node to the monitoring unit in  
30       response to an operation instruction from the monitoring unit to the node. The number of MIB corresponds to a number of pieces of notification information that are obtained from a node during a period while the monitoring unit carries out polling to one node.

35       At step S3, the monitoring unit 1 reads the number of nodes that are accommodated in each transmission line from the center router information.

At step S4, a communication order determining unit of the monitoring unit determines an order of polling the nodes according to a ratio of the total number of nodes to the number of nodes accommodated in each transmission line. This processing will be explained in detail below with reference to Fig. 3.

Fig. 3 is a flowchart that shows a processing order for determining the order of polling nodes that are to be monitored.

At step S11, the monitoring unit arranges center router information for each transmission line, and determines the order of transmission lines that are used for the polling. For example, the monitoring unit determines that the transmission lines are repeated as follows: the transmission line 1-1 → the line 1-2 → the line 1-3 → the line 2-1 → → --- → the line 3-3 → the line 3-4.

At step S12, the monitoring unit selects one transmission line according to the order of the transmission lines to be used for the polling that has been determined at step S11.

Next, the monitoring unit executes steps S13 to S15 to the transmission line that has been selected at step S12, and sequentially registers the nodes to be monitored.

In this case, the "register" means to execute the polling of the nodes that are to be monitored.

At step S13, the monitoring unit judges whether the registered number of nodes to be monitored in the transmission line selected at step S12 is equal to 0 or not. When a result of this judgement is YES, the monitoring unit proceeds to step S15 in order to register a first node to be monitored that is accommodated in the selected transmission line. When a result of this judgement is NO, the monitoring unit proceeds to step S14 in order to register a second node, and others, that are

to be monitored.

At step S14, the monitoring unit judges whether the following expression (2) is satisfied or not. When a result of this judgement is YES, the monitoring unit  
5 judges that it is necessary to register a node to be monitored, and the monitoring unit proceeds to step S15. When a result of this judgement is NO, the monitoring unit judges that it is not necessary to register a node to be monitored, and returns to step S12.

10       Total number of nodes / number of nodes accommodated  
           $\leq$  total registered number / number registered for  
each line --- (2)

In the above expression (2), the total registered  
number means the total number of nodes to be monitored  
15 that have passed step S15. The number registered for each line means the number of nodes to be monitored for each line that have passed step S15. Based on the above expression (2), the dispersion of the load of the transmission lines is averaged. For example, the number  
20 of nodes accommodated in the line 3-4 is 19, and this number is approximately a half of the number of nodes accommodated in other transmission lines. Therefore, this number is not registered each time, and the number is registered every other time.

25       At step S15, the monitoring unit registers one new node to be monitored, and updates the total registered number and the registered number for each line

Referring back to Fig. 2, at step S5, the monitoring unit calculates a processing time per one node, from a  
30 data transmission / reception quantity, a line speed of a transmission line, a maximum node response time, and the processing speed of the monitoring unit, based on the following expression (3).

Processing time per one node  
35       = (data transmission & reception quantity / line speed of a transmission line x line efficiency) + maximum node response time + processing speed of the monitoring

unit --- (3)

At step S6, the monitoring unit calculates the polling period based on the following expression (4).

Polling waiting time

5       = polling period / total number of nodes  
      - processing time per one node --- (4)

At step S7, a communication interval determining unit of the monitoring unit executes the polling to each node, based on the polling waiting time that has been  
10       calculated at step S6 and according to the order of  
      monitored nodes to be polled that has been determined at  
      step S4.

The monitoring unit carries out the polling to each node, according to the polling waiting time and the  
15       polling order, as explained above. Therefore, it is  
      possible to disperse the load of the transmission lines,  
      and avoid local traffic congestion.

In the above embodiment, the load of the transmission lines is dispersed to the whole 368 nodes.  
20       According to the present invention, it is also possible  
      to disperse the load of the transmission lines that are  
      connected to each center router to the nodes of each  
      center router independent of other center routers, based  
      on a parallel processing of the monitoring unit.

25       Further, in the embodiment shown in Fig. 1, the  
      network between the monitoring unit and the nodes has a  
      tree shape as a physical mode. However, in the present  
      invention, it is also possible to employ a star shape as  
      a physical mode.

30       Further, in the above embodiment, the monitoring  
      unit has been explained as an example. It is also  
      possible to apply the present invention to various other  
      cases. For example, it is possible to apply the  
      invention to a case in which resources are distributed to  
35       a plurality of nodes that are connected to the central  
      computer via a broadband network, or a case in which a  
      predetermined job is started at each node.

Next, the processing of a program that has been recorded on a recording medium to be used for the system for dispersing the load of a network according to the present invention will be explained.

5       A central computer that executes the system for dispersing the load of a network according to the present invention includes a communication order determining unit and a communication interval determining unit. Further, the central computer includes a central processing unit,  
10   a main memory unit like a RAM as a recording medium, an auxiliary memory unit like a magnetic disk as a recording medium, and a monitoring unit. A central processing unit (CPU) incorporates reading units for a portable recording medium like a CD-ROM and for a floppy disk. The CPU  
15   reads a program, for making the computer function as various units of the present invention recorded on the portable recording medium like the CD-ROM and the floppy disk, via the reading unit, based on a predetermined operation. The CPU loads the read program onto the main  
20   memory unit. It is of course possible to arrange such that an operator directly writes the program onto the main memory unit of the central computer via an input unit like a keyboard and a mouse, and installs the program on the auxiliary memory unit. Alternatively, via  
25   a network (a communication line), the program stored in the auxiliary memory unit like a magnetic disk as a recording medium that is installed on the computer of other client is loaded onto the auxiliary memory unit of the central computer according to the present invention.  
30   Thereafter, the program stored in the auxiliary memory unit is loaded onto the main memory unit according to need, based on the processing of the central processing unit. The central processing unit executes the program written on the main memory unit, according to the needs.

35       As explained above, according to the present invention, it is possible to provide a system for dispersing the load of a network that can avoid local

traffic congestion in a communication route within a broadband network, a method therefor, and a recording medium recorded with a program for executing this method, in data communications between a central computer and a plurality of remote nodes that are connected to this central computer via the broadband network.

Further, according to the present invention, when a plurality of remote nodes are divided into a plurality of transmission lines, the frequency of using the transmission lines is determined in proportion to the number of remote nodes that are connected to the transmission lines or in proportion to the line speed of each transmission line. Therefore, it becomes possible to disperse the load of the network more satisfactorily.